REMARKS

Reconsideration of the above-identified patent application, as amended, is respectfully requested. The present amendment is responsive to the Office Action mailed July 5, 2002. A petition for an extension of time in which to respond to the Office Action accompanies this amendment.

By the present amendment, claims 4-6 are pending in the application.

Support For Claims

Support for new claims 4-6 may be found as follows.

Claim 4

The limitation directed to the composition of the slab may be found in original claim 1, page 21, lines 6-7.

The limitation directed to the heating of the slab, hot rolling the slab, and optionally annealing the hot rolled slab may be found in original claim 1, page 21, lines 12-14.

The limitation directed to cold rolling the hot-rolled sheet may be found in original claim 1, page 21, lines 15-19.

The limitation directed to decarburization annealing the cold-rolled sheet at a temperature of 700-1000°C may be found in original claim 1, page 21, lines 20-23.

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The limitation directed to treating the cold-rolled sheet for nitriding may be found in original claim 1, page 21, lines 23-24.

The limitation directed to final annealing may be found in original claim 1, page 21, lines 27-28.

The limitation directed to the grain-oriented electrical steel sheet having a final thickness of 0.36 - 1.00 mm may be found in original claim 1, page 21, lines 15-16. See also, e.g., specification page 4, lines 3-4; page 6, lines 17-23; page 9, lines 29-30; page 13, lines 7-8; page 14, 19-27.

The C content being not greater than 0.0050% by weight after decarburization annealing may be found in original claim 1, page 21, line 29 - page 22, line 1. See also, e.g., specification page 4, lines 5-6; page 14, line 28 to page 15, line 3.

The limitation directed to setting a total N-content to 0.010 to 0.027% by weight following decarburization annealing may be found in original claim 3, page 22, lines 24-26. See, also, e.g., specification, page 13, lines 24-28.

The limitation directed to coating the nitrided sheet with an MgO annealing separation agent may be found in original claim 1, page 21, lines 25-26.

The limitation directed to subjecting the MgO coated sheet to final annealing as a coil having an inside

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diameter of 200 - 1500 mm may be found in the specification, e.g., at page 7, lines 24-28.

Page 15, lines 10-14 of the specification discussed the requirement that the deviation degree ($\Delta\theta$) of crystal orientation in grains of a diameter exceeding 5 mm is required to be in the range of $\Delta\theta$ = 0.2 - 4 degrees. Page 15, lines 22 to 26 discloses that a method of controlling $\Delta\theta$ (deviation degree of grains of specified diameter) is to conduct final finish annealing with a coil having a diameter suitable to provide the desired grains.

The SF value (shape factor representing the boundary configuration characteristics of the sheet grains) being less than 0.8 (average value) is discussed in the specification, e.g., at page 15, lines 4-9. The formula for determining SF is discussed in the specification, e.g., at page 8, lines 26-29. See original claim 1, page 22, lines 4-10.

Magnetic flux density B_8 of not less than 1.83T and core loss $W_{17/50}$ (w/kg) of not more than 3.3 x t + 0.35 is disclosed in the specification, e.g., at page 10, lines 7-14 and Fig. 3. See original claim 1, page 22, lines 2-3 and 14-15.

Claim 5

The coil inside diameter of 600 mm of new dependent claim 5 is disclosed in the specification, e.g., at page 17, lines 7-8.

Claim 6

New dependent claim 6 corresponds to original dependent claim 2.

New matter is not being presented by the present amendment.

§112, ¶2

Claims 1-3 were rejected under 35 U.S.C. §112, second paragraph, as being indefinite. The Office Action objected to the wording "as" in claim 1, line 7.

By the present amendment, claims 1-3 have been canceled.

In new independent claim 4, the wording of the portion of claim 4 corresponding to the objected to portion of claim 1 has been revised to delete the word "as".

It is respectfully requested that the rejection under 35 U.S.C. §112, second paragraph, as applied to new claims 4-6, be withdrawn.

§103

Claims 1-3 were rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,190,597 to Kobayashi et al. or U.S. Patent No. 4,979,996 to Kobayashi et al. in view of U.S. Patent No. 4,054,471 to Datta, U.S. Patent No. 3,969,162 to Henke or U.S. Patent No. 4,318,758 to Kuroki et al.

These rejections, as applied to new claims 4-6, are respectfully traversed.

The Present Invention

The present invention is characterized in that the cold-rolled sheet has a final thickness of 0.36 - 1.00 mm.

The C-content is set to not greater than 0.0050% by weight after decarburization annealing of the sheet.

The total N-content is set to 0.010 - 0.027% by weight after nitriding treatment of the sheet in NH_3 gas following the decarburization annealing.

The nitrided sheet is coated with an annealing separation agent consisting essentially of MgO and subjected to final annealing as a coil having a coil inside diameter within a range of 200 - 1500 mm (specification page 7, line 26) to obtain grains of a selected diameter. Its grains of a diameter exceeding 5 mm have a crystal orientation deviation of 0.2 - 4 degrees in relation to that at the grain center, and a post-final-annealing SF value of less than 0.80, where SF is defined as

$$SF = (\text{grain area} \times 4\pi)/(\text{grain boundary length})^2.$$

The magnetic flux density B_8 of the sheet is not less than 1.83T and core loss $W_{17/50}$ (w/kg) of the sheet is not more than 3.3 x t + 0.35, where t is sheet thickness.

SF value is the shape factor representing the boundary configuration characteristics of the sheet grains.

Crystal orientation deviation is $\Delta\theta$.

The Prior Art

U.S. Patent No. 5,190,597 to Kobayashi et al (US `597)

US `597 mentions a final texture-annealing atmosphere, and discloses a sheet thickness of 0.30 mm in Example 1 and 0.23 mm in Example 2. The discovery of the present invention that controlling the SF and $\Delta\theta$ values is highly effective for improving the core loss properties in thick grain-oriented electrical steel sheet having a thickness of 0.36 to 1.00 mm is new, and not disclosed or suggested in US `597.

U.S. Patent No. 4,979,996 to Kobayashi et al (US `996)

Figures 1 and 2 of US `996 show nitriding conditions, and Figure 3 shows the secondary recrystallization and finish annealing conditions. However, `996 does not suggest anything about secondary recrystallization grain SF and $\Delta\theta$ values. Table 1 of this citation discloses a sheet thickness of 0.23 mm, which is not the same as the thickness of the sheet of the present invention.

U.S. Patent No. 4,054,471 to Datta (US `471)

US `471 provides a method for producing grain-oriented electrical steel sheet with a permeability of at least 1870 (G/Oe) at 10 oersteds. The method comprises hot-rolling a slab containing 0.02 to 0.06% C, 0.0006 to 0.0080% B, up to 0.0100% N, not less than 0.008% Al and 2.5 to 4.0% Si and subjecting the hot-rolled sheet to the usual

treatments to obtain sheet having a final thickness of not more than 0.020 inch (0.5 mm). The sheet is annealed by heating it to 1550 to 2000°F (843 to 1093°C) in an atmosphere containing H_2, and is then subjected to decarburization annealing to bring the C-content down to less than 0.005%. The specification describes a sheet thickness of not more than 0.5 mm, but the examples do not mention a final sheet thickness. Moreover, `471 contains nothing suggesting the effect of combining the SF value and the $\Delta\theta$ value that are important features of the present invention (specification Figure 2).

U.S. Patent No. 3,969,162 to Henke (US '162)

US `162 is a method of producing grain-oriented electrical steel sheet by using a planetary mill to roll a slab to a thickness of 0.060 to 0.150 inch (1.5 to 2.5 mm) at a temperature not lower than the MnS precipitation temperature, cooling the rolled sheet to 600 to 1500°F (316 to 816°C) and rolling it to a thickness of 0.020 to 0.030 inch (0.5 to 0.75 mm). The 0.020 to 0.030 inch is a <u>semi-finished</u> sheet thickness. The specification mentions a final sheet thickness of 0.012 inch (0.3 mm). Moreover, `162 contains nothing suggesting that thick grain-oriented electrical steel sheet with a thickness of 0.36 to 1.00 mm and excellent core loss properties can be obtained by combining the SF value and the $\Delta\theta$ value which are important features of the present invention.

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U.S. Patent No. 4,318,758 to Kuroki et al. (US `758)

US `758 provides a method for producing grain-oeeeriented electrical steel sheet with a {hk0} <001> orientation. The examples in the specification describe only a final sheet thickness of 0.30 mm. The specification describes the technology as being applicable to up to a final thickness of 0.5 mm. However, `758 discloses nothing about the finding that characterizes the subject invention, that thick grain-oriented electrical steel sheet 0.36 - 1.00 mm thick with excellent core loss properties can be obtained by controlling the grain SF and transgranular deviation ($\Delta\theta$). `758 contains nothing suggesting the effect of combining the SF value and the $\Delta\theta$ value that is an important feature of the present invention (specification Figure 2).

Patentability

Sheet thickness of 0.36 to 1.00 mm

In the prior art, the tendency has been to reduce the thickness of grain-oriented electrical steel sheet in order to improve the core loss properties. Specifically, the thickness was reduced to 0.35 mm or less, and more preferably to 0.23 mm or less.

Laminations of grain-oriented electrical steel sheets are used to make transformers, and using thicker sheet reduces the amount of work needed to make a core of a given size. From tranformer manufacturers, there is a

strong demand for ways to reduce the number of lamination steps and improve productivity. A sheet thickness of 0.35 mm represents a balance between steel manufacturing ease, including in terms of cost, and the sheet thickness sought by transformer manufacturers. Up to this point, industrial products have relied on steel sheet up to 0.35 mm thickness. See specification, page 6, lines 11-20.

The present invention overcomes this thickness barrier of up to 0.35 by making it possible to use sheets having a thickness of 0.36 mm or more.

Controlling SF and $\Delta\theta$ values

The present invention is the first to control the SF and $\Delta\theta$ values to thereby make it possible to produce thick grain-oriented electrical steel sheet having excellent core loss properties. In order to adjust the inhibitor strength, the present invention uses nitriding treatment to set the N-content of the steel sheet at 0.010 to 0.027%. Final annealing is used to control the SF to less than 0.80 (specification page 15 lines 20-21). Also, at the time of the final anneal, the $\Delta\theta$ is controlled by controlling the inside diameter of the coil into which the steel sheet is wound, which is done by selecting an inside diameter of from 200 to 1500 mm (specification page 7, lines 25-27 and page 15 lines 24-26). These conditions are shown in Figure 2 of the present specification. This knowledge was first established by the present invention.

`758 and `471 broadly disclose sheet having a final thickness of 0.5 mm (with no specific example) and disclose or suggest nothing about controlling the SF and $\Delta\theta$ values.

`597 and `996 have disclosures relating to nitriding treatment and the final annealing atmosphere, but show no awareness about the SF and $\Delta\theta$ values. They also have nothing that suggests that when the secondary recrystallization grain SF is controlled to less than 0.80 and the $\Delta\theta$ value to 0.2 to 4°, the core loss $W_{17/50}$ (w/kg) of the sheet does not exceed 3.3 x t + 0.35.

The Office Action states (on page 4, lines 4-5 of the Action) that the process steps overlap the references, but there is no disclosure or suggestion about, at the time of the final annealing, controlling $\Delta\theta$ by controlling the inside diameter of the coil into which the steel sheet is wound, by selecting an appropriate coil inside diameter. Neither is there anything suggesting a link between coil inside diameter and $\Delta\theta$.

The present invention was the first to achieve a low core loss by using nitriding treatment to set the N-content of the steel sheet to 0.010 to 0.-27% and selecting an inside diameter of from 200 to 1500 mm for the final annealing.

This results in the required SF and $\Delta\theta$ values and results in a 0.36 - 1.00 mm thick grain-oriented electrical

steel sheet having a low core loss and high magnetic flux density.

It is therefore submitted that new independent claim 4, and claims 5 and 6 dependent thereon, are patentable over U.S, Patent No. 5,190,597 to Konayashi et al. or U.S. Patent No. 4,979,996 to Kobayashi et al. in view of U.S. Patent No. 4,054,471 to Datta, U.S. Patent No. 3,969,162 to Henke or U.S. Patent No. 4,318,758 to Kuroki et al.

Therefore, new claims 4 to 6 are patentable.

CONCLUSION

It is submitted that in view of the present amendment and foregoing remarks, the application is now in condition for allowance. It is therefore respectfully requested that the application, as amended, be allowed and passed to issue.

Respectfully submitted,

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